



# Diagnostics And Data Fusion of Robotic Sensors



**Developer:** Foster Miller Technology, Inc.  
**Contract Number:** DE-AR21-95MC32093  
**Crosscutting Area:** Robotics

## Deactivation & Decommissioning FOCUS AREA

### Problem:

In the remediation of hazardous waste sites, robotic systems must be reliable to avoid failures and the subsequent possible exposure of personnel to hazardous environments. Safe, efficient clean-up operations also require accurate and complete 3-D computer models of a task space. A complete surface description typically requires multiple-sensor data sets, and it is difficult to merge the resulting data sets into one coherent model.

### Solution:

A comprehensive monitoring and diagnostic system will significantly enhance the reliability of robotic remediation systems. By detecting incipient faults in time for corrective action, such a system dramatically decreases the possibility of on-site failures and the problems that follow. To complement this capability, software for task-space mapping will be developed. This software will merge data from different sensor poses and assign a

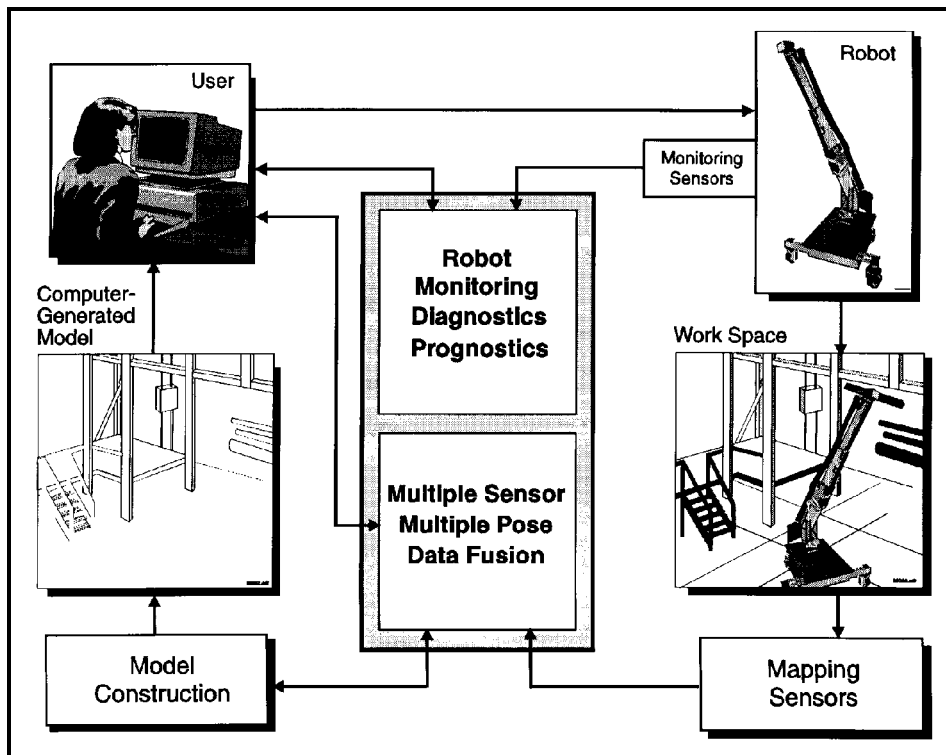
confidence metric that estimates the reliability of the data. The resulting surface map will provide robot operators with a complete, accurate description of a task space.

### Benefits:

- Reduces risk of robotic failure during remediation
- Warns of degradation before failure occurs
- Increases safety through more complete and accurate 3D maps
- Improves efficiency by enhancing operator's understanding of a task space
- Provides greater spatial clearance for robotic manipulators
- Provides an estimate of data confidence

### Technology:

The sensors, data acquisition, and expert system elements needed for monitoring and diagnostic systems exist and have been used successfully on continuously operating machinery such as turbines and pumps. However, very little has



been done to characterize intermittent systems such as robots and machine tools. One goal of this effort was to extend these existing algorithms and techniques to address the needs of intermittently operating machinery and to develop a prototype monitoring and diagnostic system for robotic applications. Redzone's ROSIE robotic platform was chosen as the model. A conceptual design for the prototype monitoring and diagnostic system was developed under this task.

A second goal was to develop a data fusion software module. Data from different poses of a mapping sensor are combined into an occupancy map, using probabilistic reasoning to fuse the 3-D data points in accordance with their precision. Following this data fusion, an expert system provides a confidence metric that estimates the reliability of the data. Data visualization and conversion to CAD format are supported by an Interactive Computer-Enhanced Remote Viewing System (ICERVS), being developed in a separate project. ICERVS's capabilities are enhanced somewhat, so that it can function as the graphical user interface (GUI) for the fusion software.

### **Project Conclusion:**

This project was completed in June 1998. The main product of this effort was the development of registration and data fusion capabilities for ICERVS software. The software will integrate into the facility mapping system (FMS) development effort for the robotics

applications being coordinated by the Oak Ridge National Laboratory (ORNL) Robotics and Process System Division with the other DOE laboratories and a number of universities (Florida State, University of Michigan, Carnegie Mellon University, University of Tennessee, etc.). An Application Programming Interface (API) was also added for the convenience of the software developers. This API would allow users to write their own code and effectively insert into the ICERVS software framework. This would make ICERVS the standard for FMS on which enhanced capabilities could be added later.

The other work associated with the effort included evaluation of diagnostic techniques for robotics reliability. An evaluation of state-of-the-art techniques was completed and based on this work. The contractor was awarded a grant for further work by the Environmental Management Science Program (EMSP).

### **Contacts:**

Foster Miller Technology, Inc. develops advanced technology for new commercial products, performs contract research and development, and provides technical services to government and commercial clients. Business focus areas include custom monitoring and diagnostic systems, advanced measurement systems, unique power and energy systems, and specialty machinery components. For information on this project, the contractor contact is:

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